

# 2021 Monsoon Outlook

For Central & Northern New Mexico



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Courtesy: Randall Hergert



Courtesy: Stu Ostro



Courtesy: Derrick Neill



Courtesy: Tim Fitzharris/Minden Picture



Courtesy: William Stone Photography

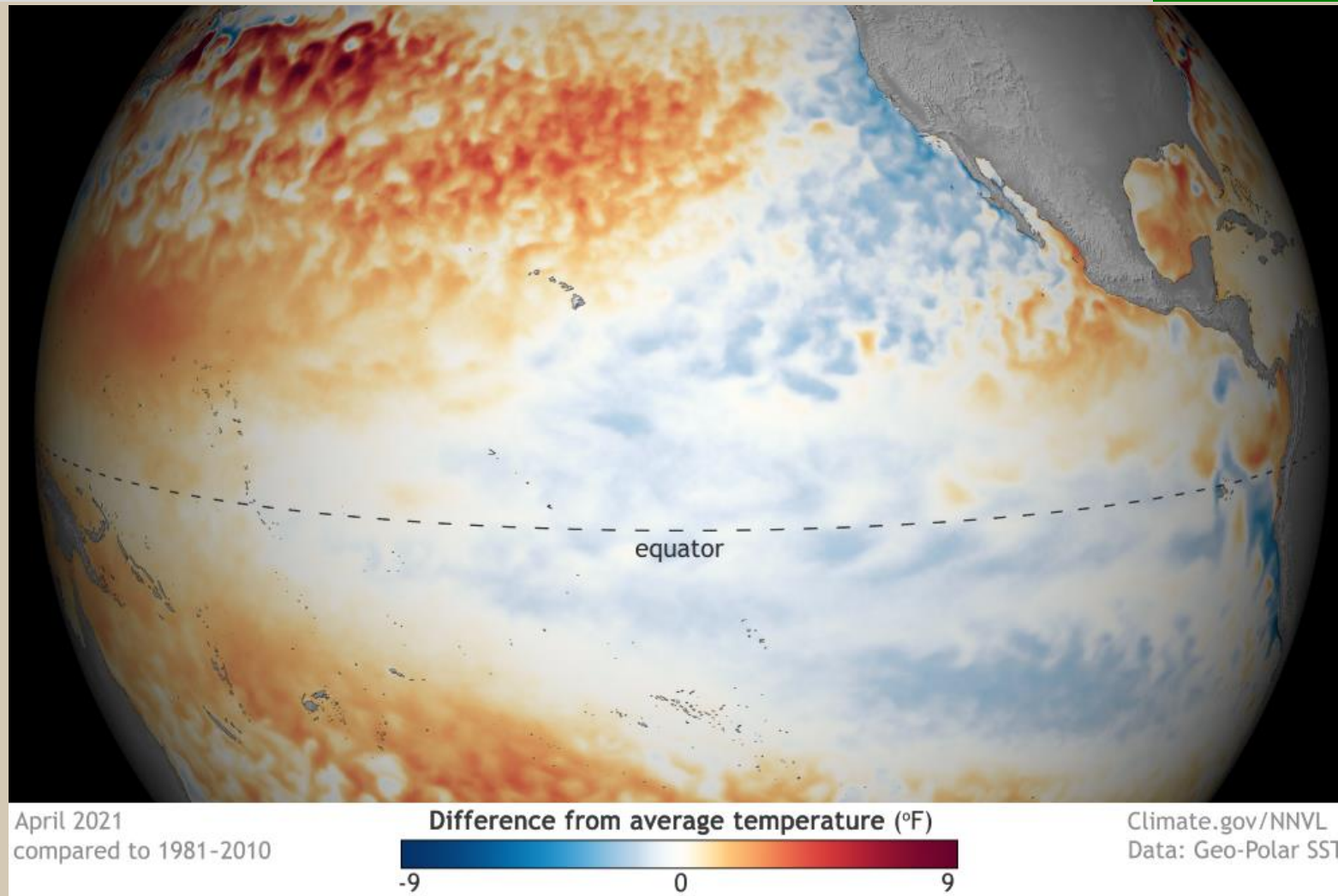
Will this year's North American Monsoon (NAM) show up? After the end of La Niña, it looks like it just might.



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**Figure 1.** April 2021 sea surface temperature departure from the 1981-2010 average showing a neutral central and eastern equatorial Pacific Ocean. Image from Climate.gov.

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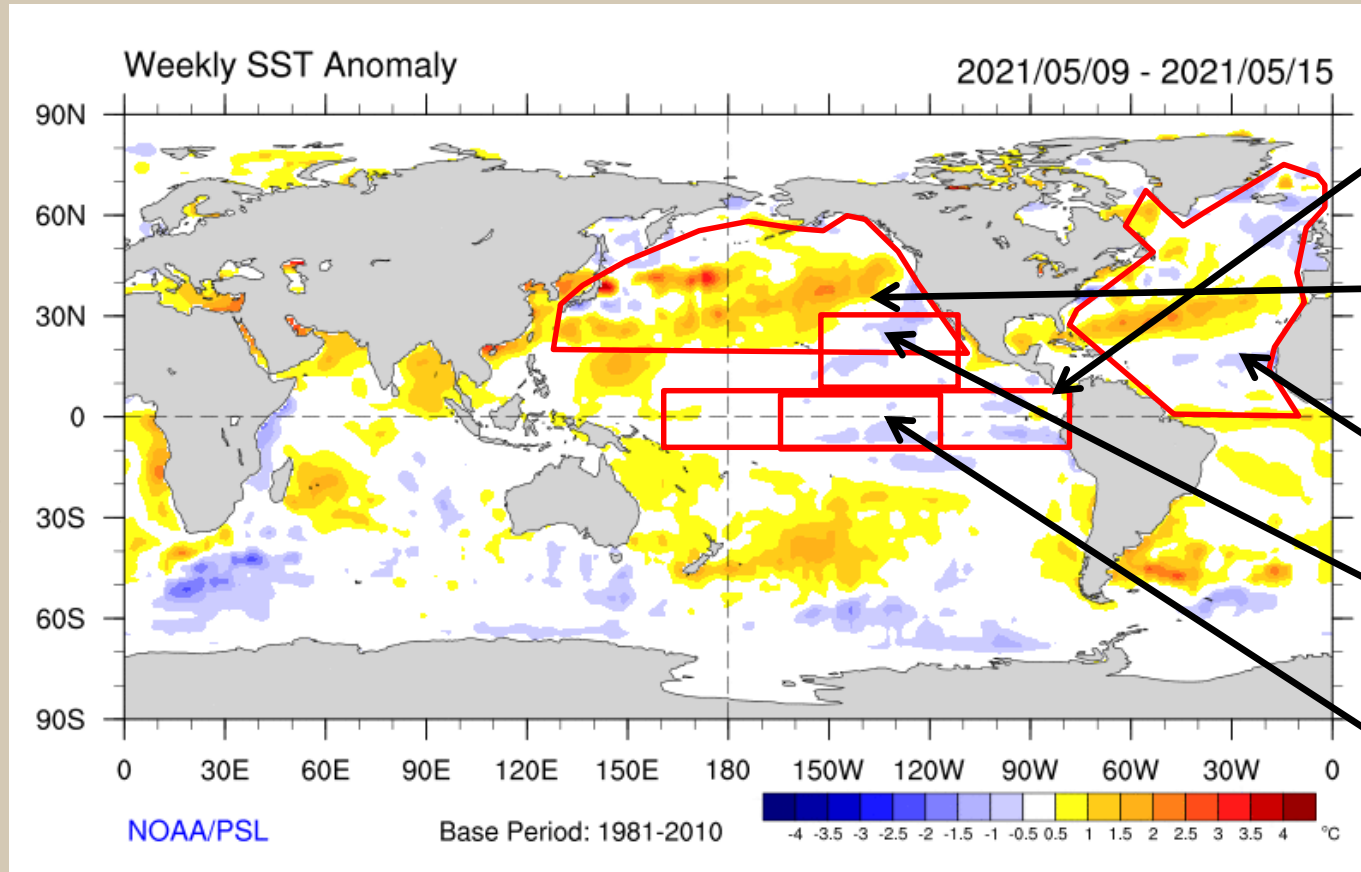
## Current Sea Surface Temperatures (SSTs)



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\*SSTs are what drive tropical & sub-tropical thunderstorms. It's these thunderstorms that drive global weather & climate.



➤ Multivariate ENSO Index (MEI) for MAR-APR 2021: **-1.0**

➤ Pacific Decadal Oscillation (PDO) for APR 2021: **-0.91**

➤ Atlantic Multidecadal Oscillation (AMO) for APR 2021: **+0.065**

➤ Pacific Meridional Mode (PMM) for APR 2021: **M**

➤ Oceanic Niño Index (ONI) (uses Niño 3.4 region - inner rectangle) for FMA 2021: **-0.8**

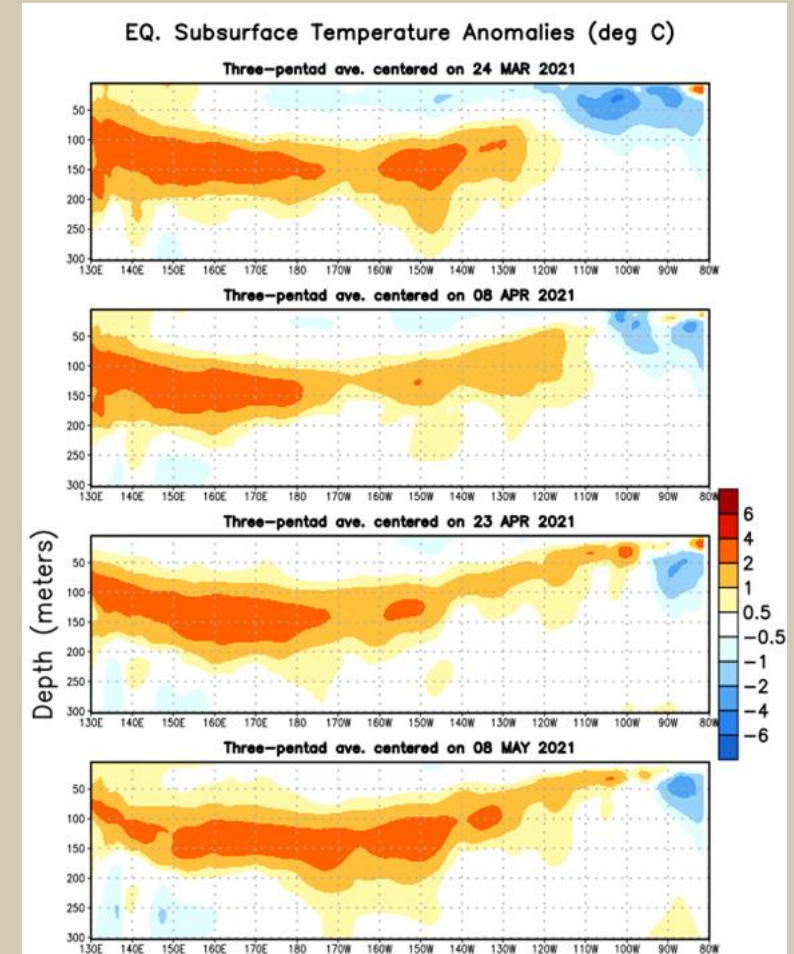
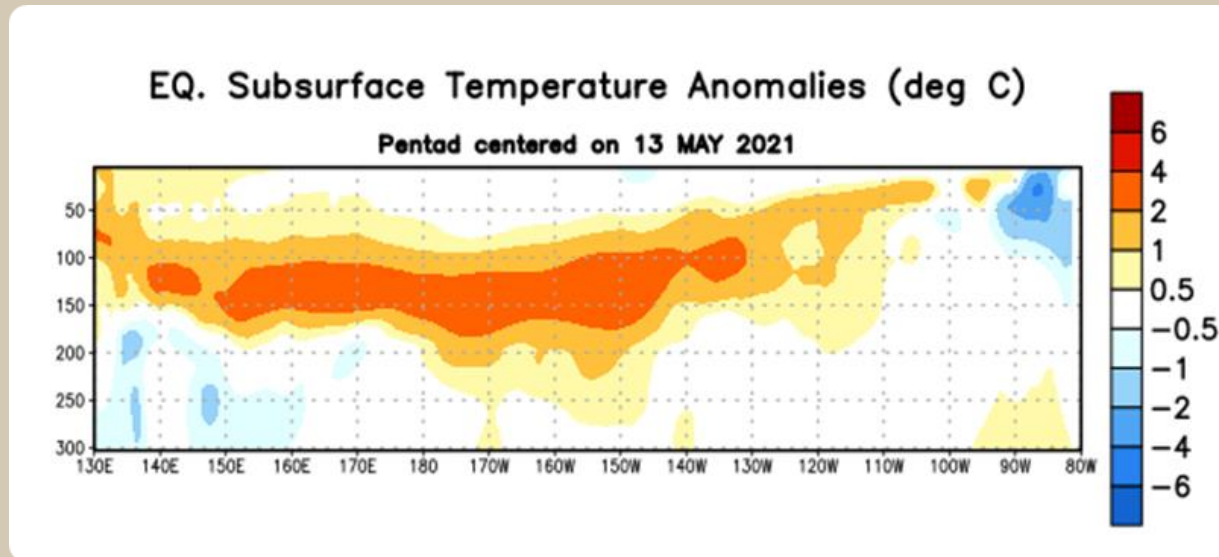
**Figure 2.** SST Anomalies in the Equatorial Pacific Ocean in early May 2021 showing that La Niña has ended and neutral conditions have developed.

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## Sub-surface Temperatures



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**Figures 3-4.** Sub-surface temperature anomalies at the equator. Sub-surface temperatures often lead surface temperatures by several months. An increasing amount of warm water under the surface provides confidence in climate models that are forecasting neutral conditions through fall 2021.



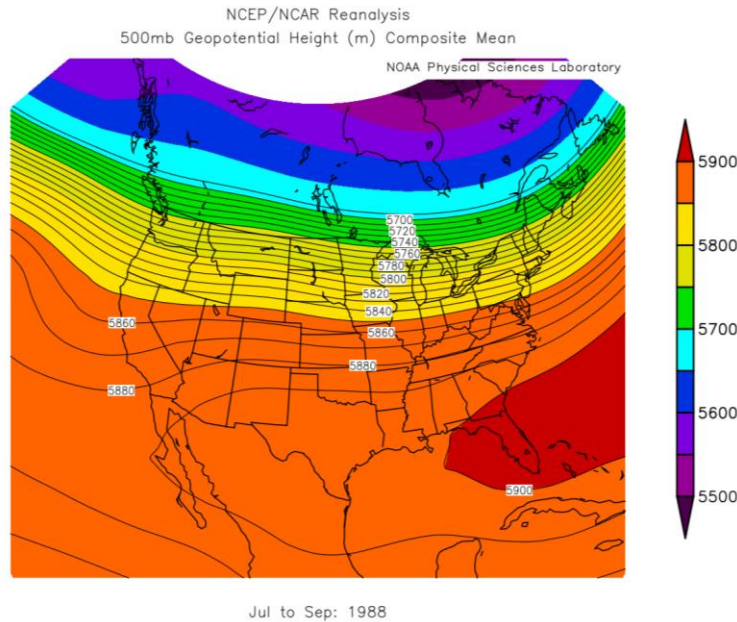
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## Why the NAM is So Tough to Predict

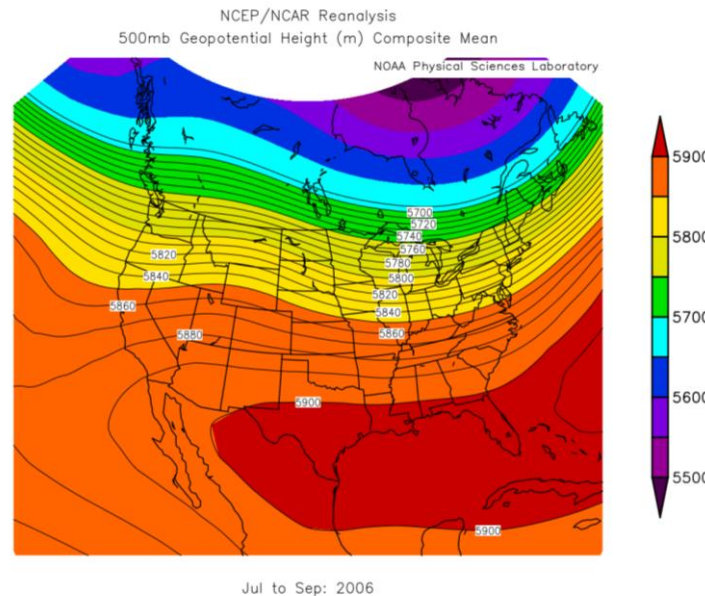


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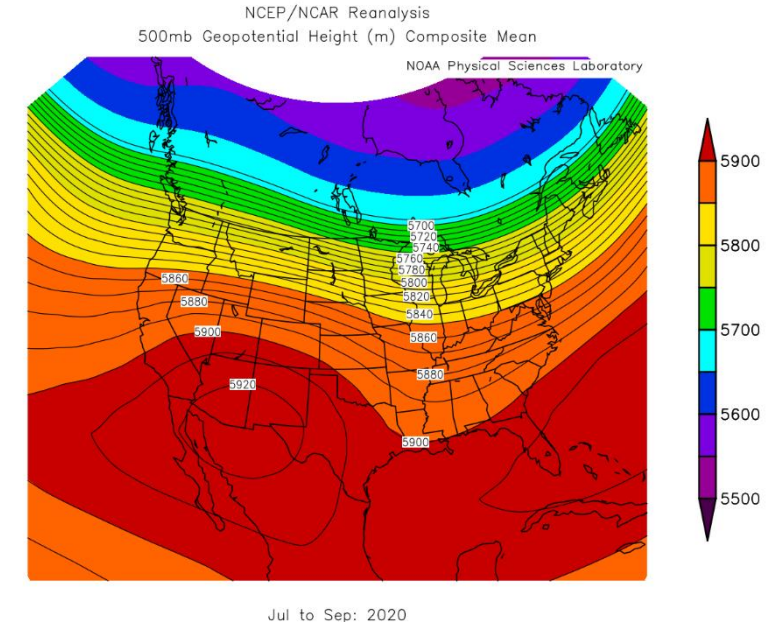
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Jul to Sep: 1988



Jul to Sep: 2006



Jul to Sep: 2020

**Figures 5-7.** Why is the North American Monsoon (NAM) so difficult to predict? There are many reasons but the main difficulty has to do with a lack of ability to predict the placement and strength of the subtropical high which sets up near the Four Corners each and every summer. This subtropical high develops due to tropical and subtropical thunderstorms in the eastern Pacific, Mexico and Central America shifting northward with the sun angle. The rising air associated with these thunderstorms has to come back down due to the fact that there's a stability lid on the lower atmosphere (temperatures begin rising with height) referred to as the tropopause. Then there's the subtropical and polar jet streams that influence how this high shifts during the months of July, August and September. If there is prolonged tropical and subtropical convection in the right locations in the eastern Pacific Ocean, a subtropical jet stream will become stronger than average off of the southern California coast and so will the associated upper-level trough that sets up several hundred miles west of the southern CA coast. It's the fluctuations in strength associated with this trough that can send the Four Corners' High (FCH) east of NM, developing a prolonged southerly flow (clockwise flow around the high to the east and counterclockwise flow associated with the low/trough to the west) that sends moisture northward into AZ/NM. Global climate models are not "convective allowing" which makes the NAM such a challenge to predict. Additionally, while the lack of soil moisture correlates well to the much stronger Asian Monsoon, it doesn't necessarily work well for the NAM. There have been many spring and early summer seasons dating back to the late 1990s when soil moisture in the Western U.S. was below to well below average and the NAM precipitation ended up being below to well below average.

Then there are climate change impacts to consider. The polar jet stream is not as continuous as it once was. A "uniform" or continuous westerly jet stream can act on the FCH, forcing it east at times. Take a look at the difference in 500 mb (~18K feet MSL) heights between the two most rigorous monsoon seasons, 1988 and 2006, and last year. The FCH in JAS 2020 was stronger (due to a warming planet and stronger than average Hadley/Ferrel Cells) and likely much more difficult to displace.

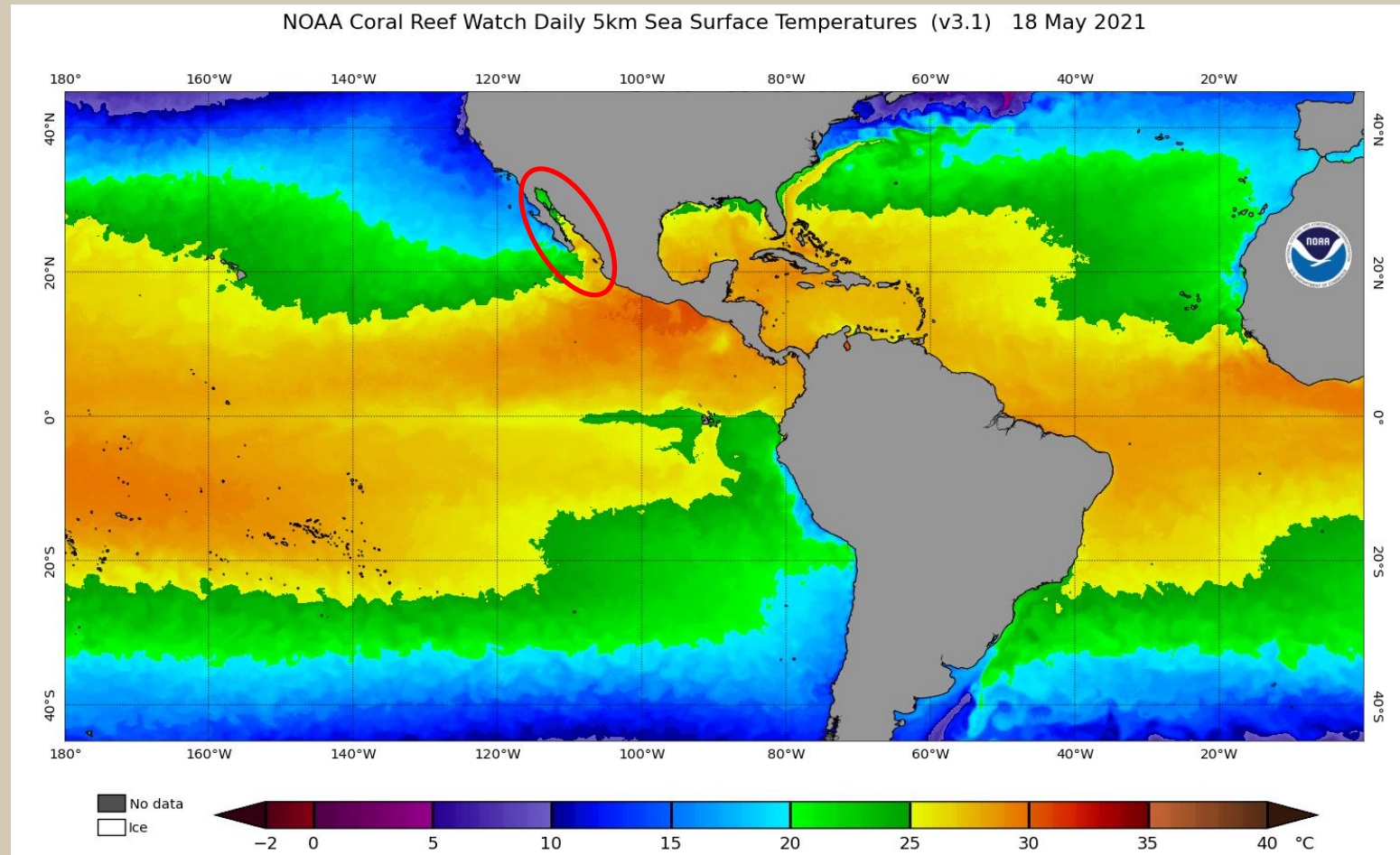
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**Figures 8.** Sea Surface Temperatures (SSTs) in the Western Hemisphere in mid May 2021 showing warmer waters ( $< 26^{\circ}\text{C}$ ) water already making their way into the Gulf of California (GOC). A previous study (Mitchell et al., 2002) showed that monsoon precipitation does not occur prior to the GOC exceeding  $26^{\circ}\text{C}$ .

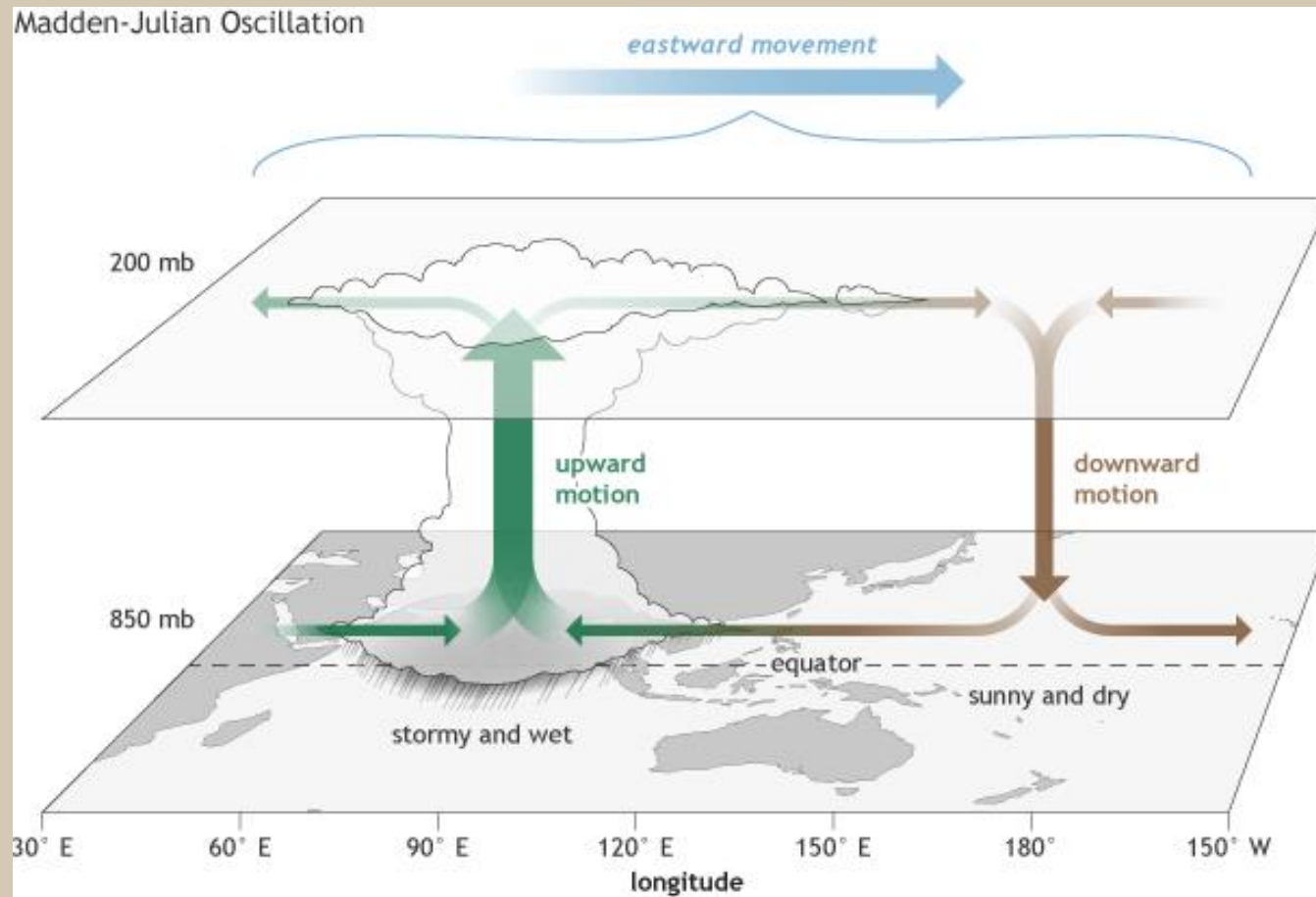
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## Madden-Julian Oscillation (MJO)



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**Figure 9.** The MJO is an area of enhanced thunderstorms that travels around the world every 30 to 60 days from west to east along/near the equator. Ahead and behind the active stormy area are areas of suppressed convection and drier conditions. The MJO affects near-surface wind patterns, because the rising air in the stormy area causes surface winds to blow toward the active area. The MJO can play a role in New Mexico's weather at any time of year but it tends to have its greatest impacts during September.



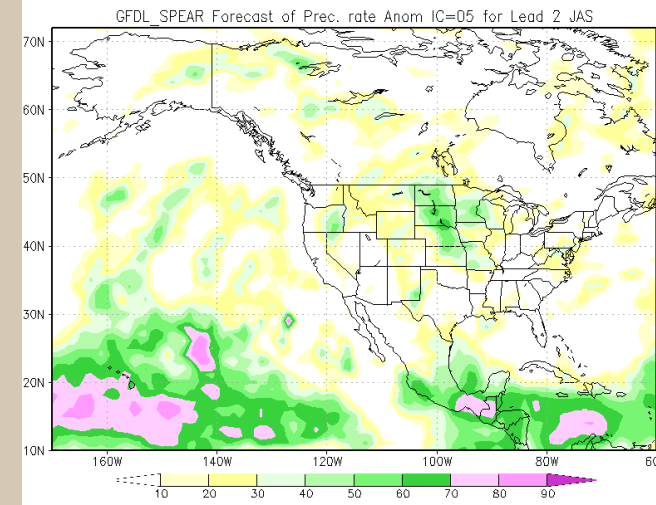
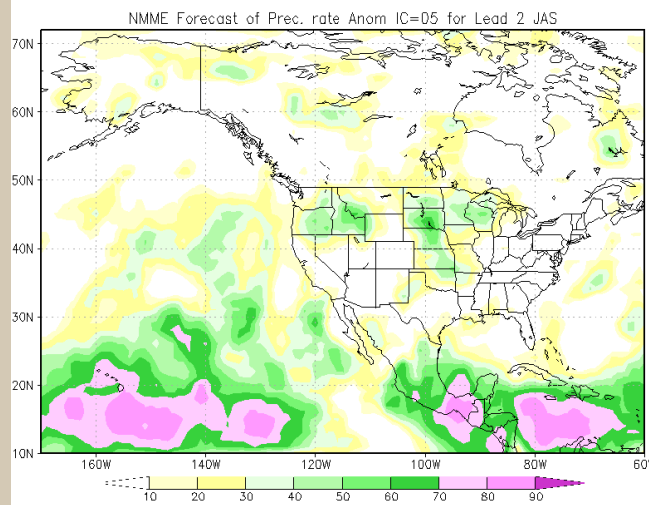
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## Precipitation Forecasts for July, August and September (JAS)

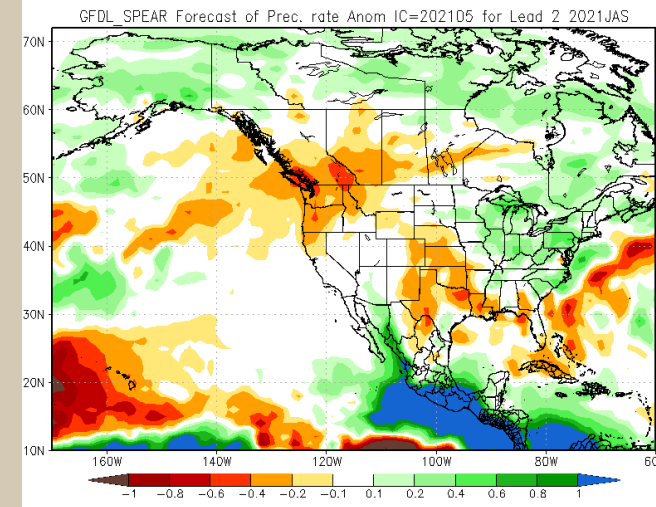
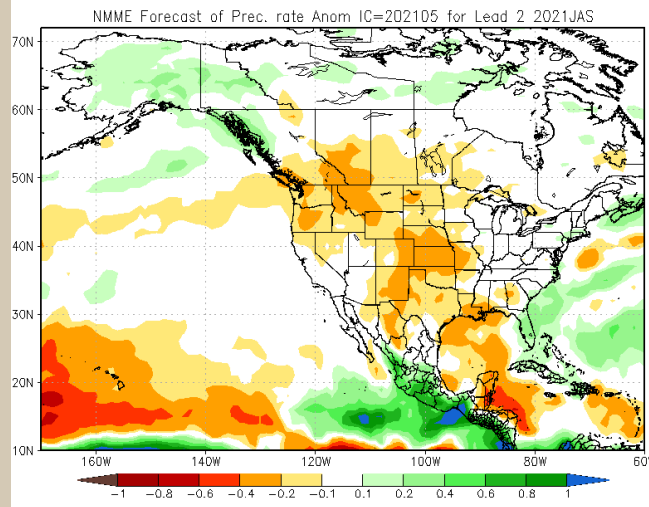


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Forecast Skill →



Precipitation rate  
anomaly  
forecast →



**Figures 10-13.** Climate model precipitation rate anomaly plots from the two climate models which have the highest forecast skill percentages (top images), the North American Multi-Model Ensemble (NMME), and the Geophysical Fluid Dynamics Laboratory (GFDL\_SPEAR) model. Both model forecasts (bottom images) are forecasting near to slightly below average precipitation for July, August, and September (JAS) for western and central New Mexico with below average precipitation east.



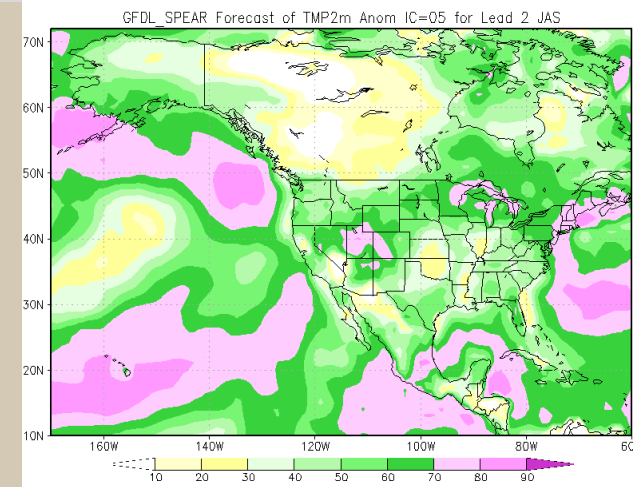
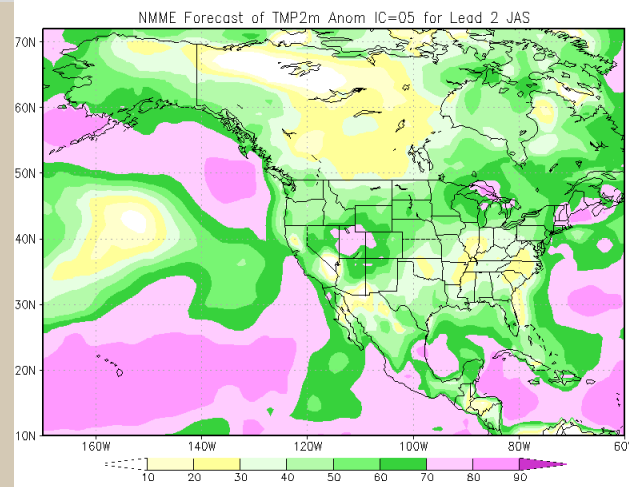
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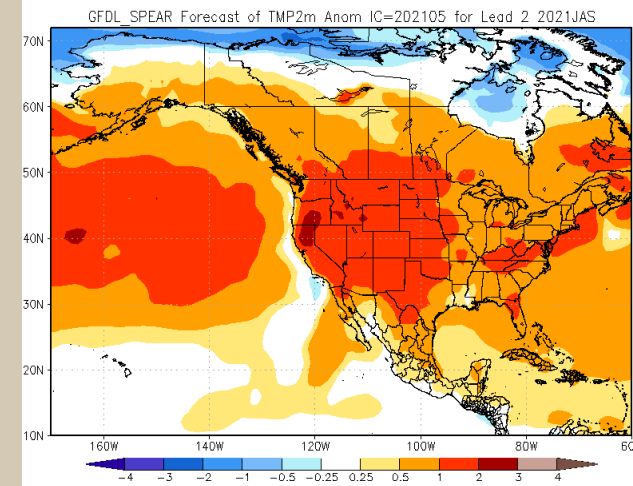
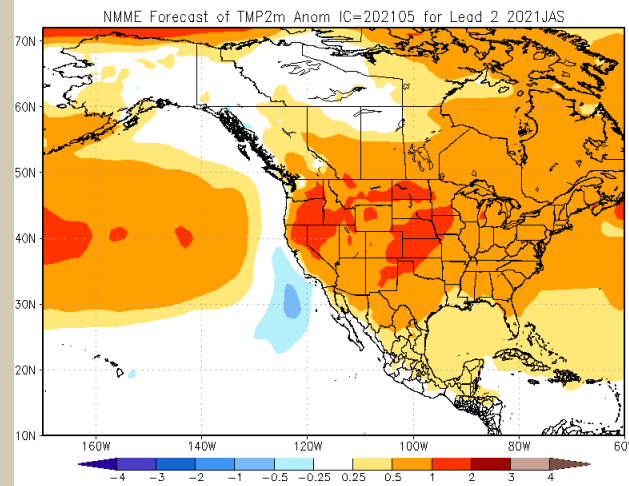
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## Temperature

Forecast Skill



Temperature  
anomaly forecast



**Figures 14-17.** Climate model temperature anomaly plots from the three climate models which have the highest skill percentages (top images), the North American Multi-Model Ensemble (NMME) and the GFDL\_SPEAR model. Model forecasts (bottom images) indicate slightly above to above average temperatures in JAS.

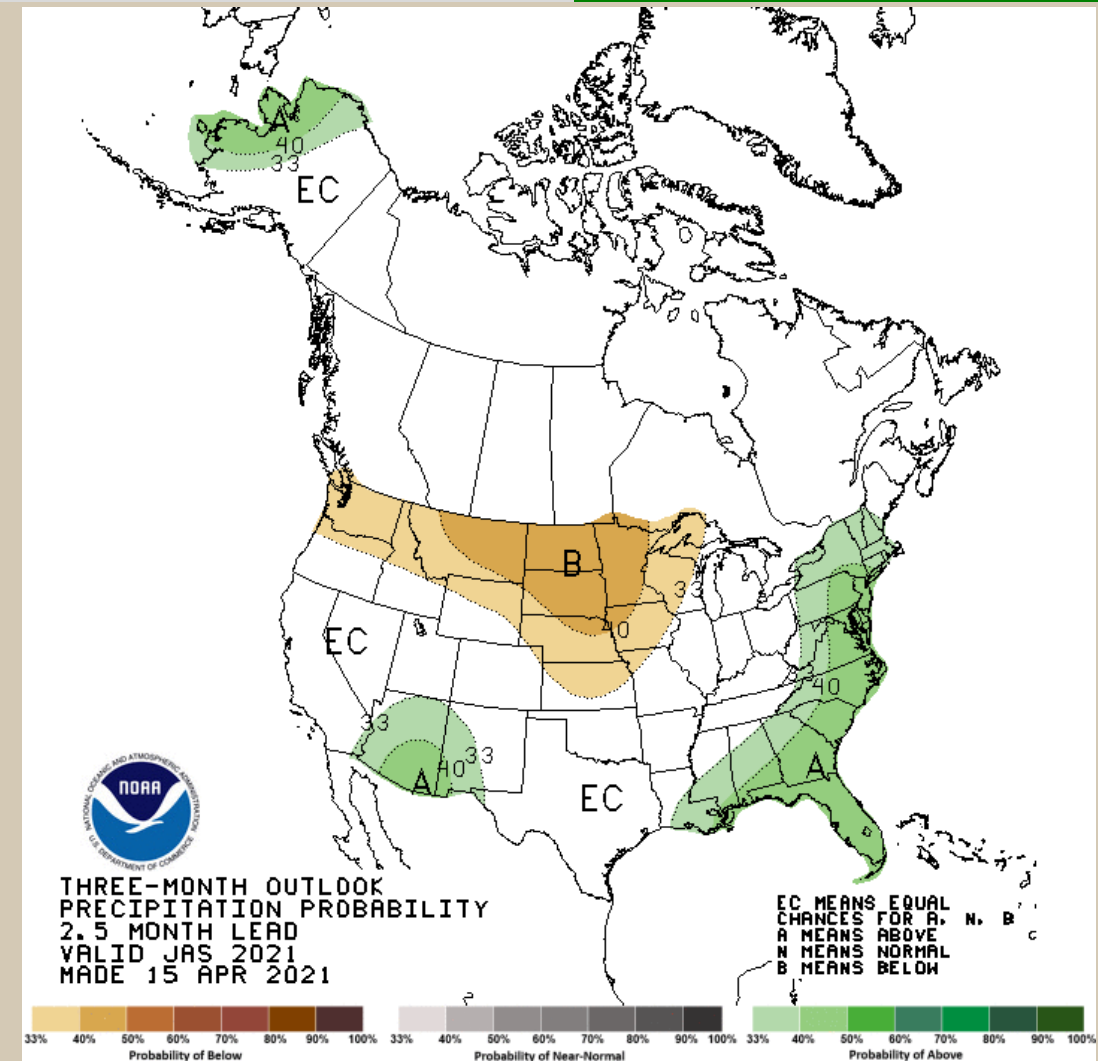
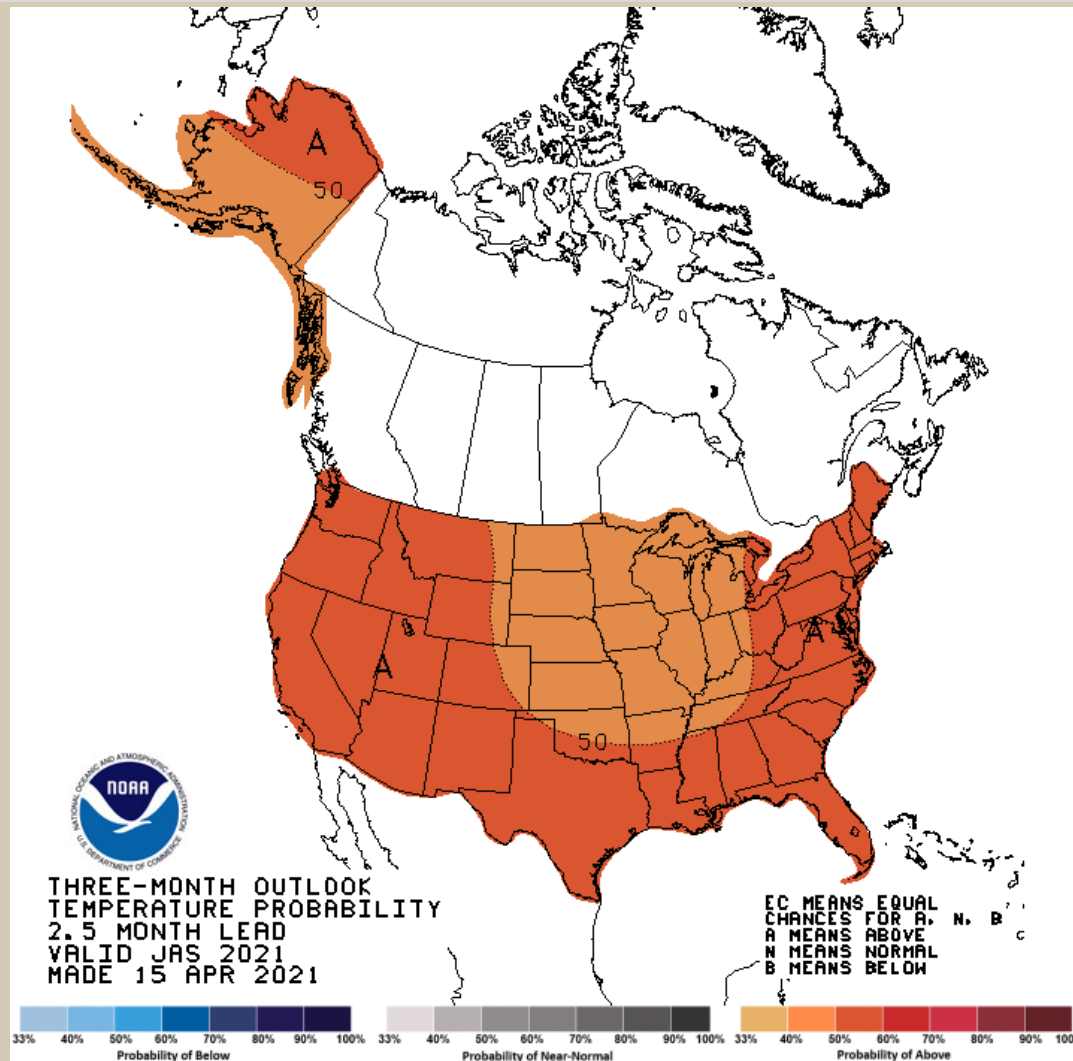
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**Figures 20-21.** CPC agrees with the climate model consensus of near to slightly above average chances for above average precipitation for southern AZ and southwest NM and above average temperatures.

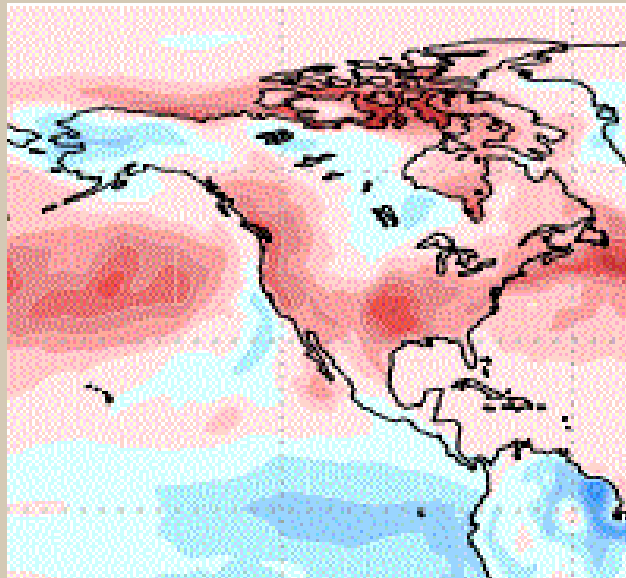


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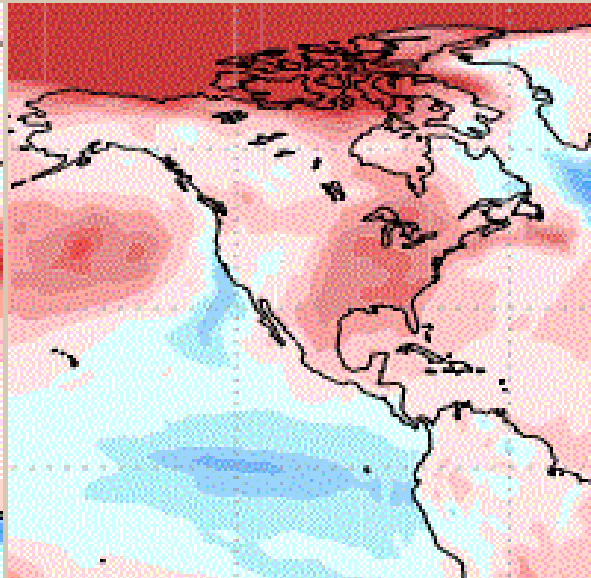
Japan Agency for Marine-Earth Science and Technology (JAMSTEC) – SINTEX-X



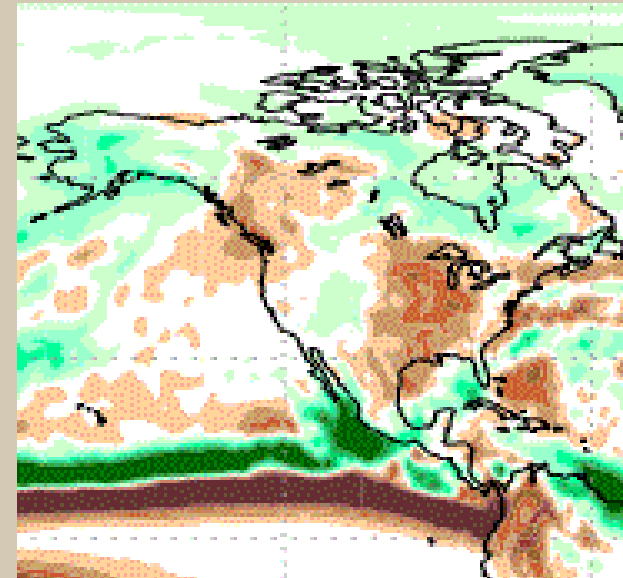
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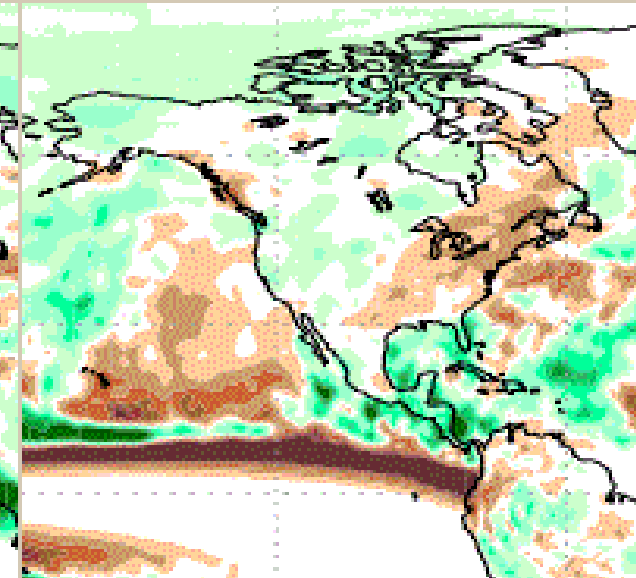
June, July & August 2021 –  
Difference from Average  
Temperature



September, October &  
November 2021 – Difference  
from Average Temperature



June, July & August 2021 –  
Difference from Average  
Precipitation



September, October &  
November 2021 – Difference  
from Average Precipitation

**Figures 22-25.** April 2021 JAMSTEC SINTEX-X climate model forecasts showing a similar forecast for the NAM.

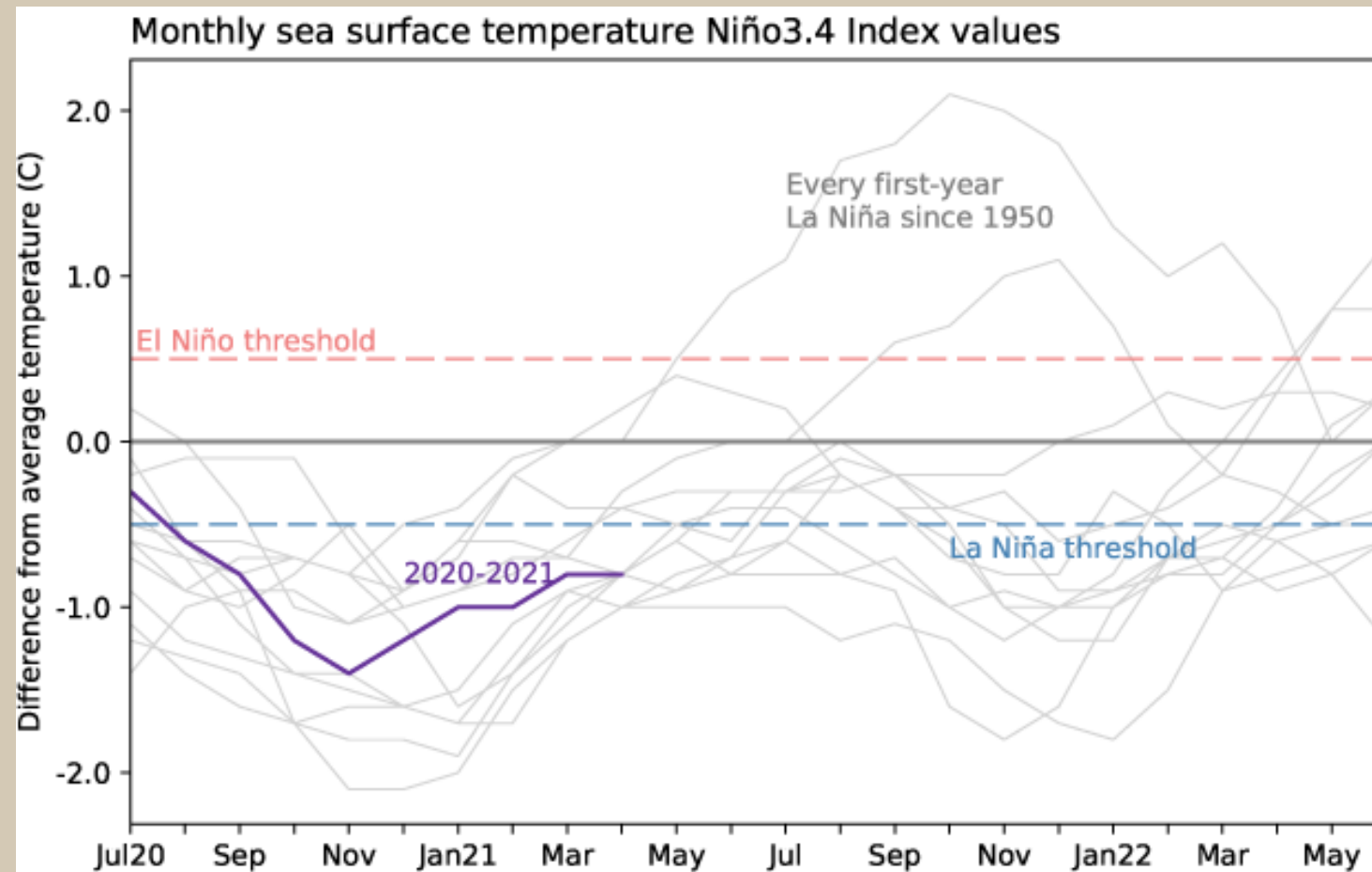
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## Multivariate El Niño Index (MEI) - Analog Years



**Figures 26.** Monthly sea surface temperature in the Niño 3.4 region of the tropical Pacific for 2020-21 (purple line) and all other years starting from first-year La Niña winters since 1950. Graph by Emily Becker based on ERSSTv5 temperature data. A “double-dip” La Niña like 2016 and 2017 is in the cards once again late this year but the odds favor neutral conditions (49%).

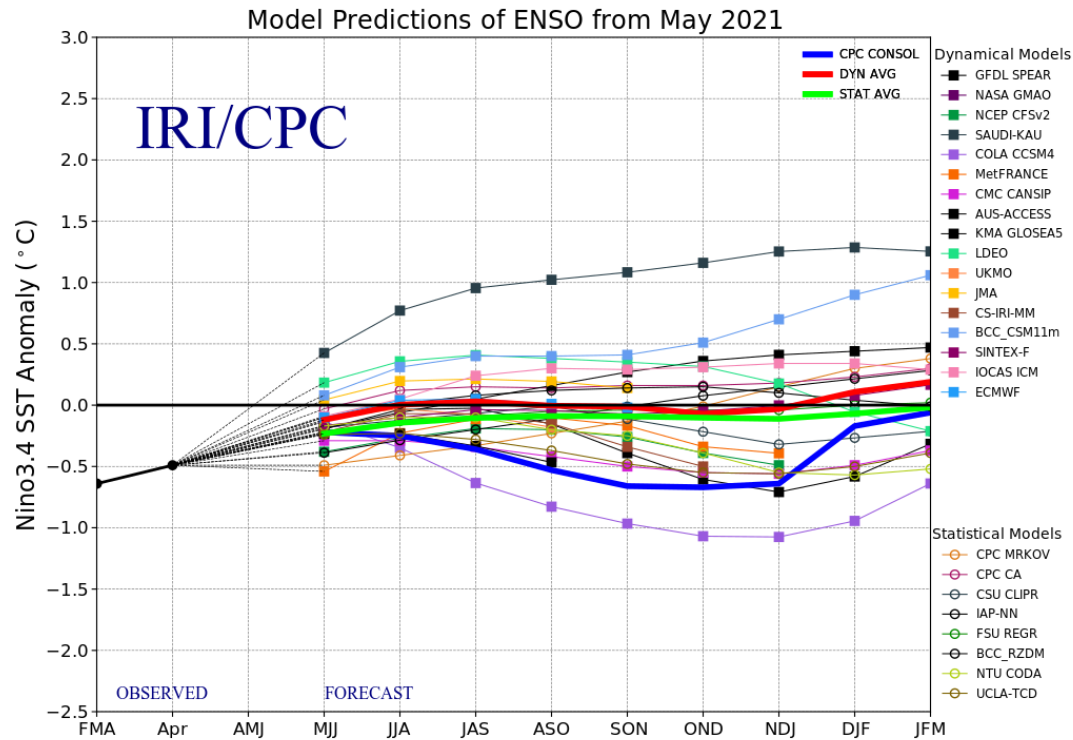


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## ENSO Predictions

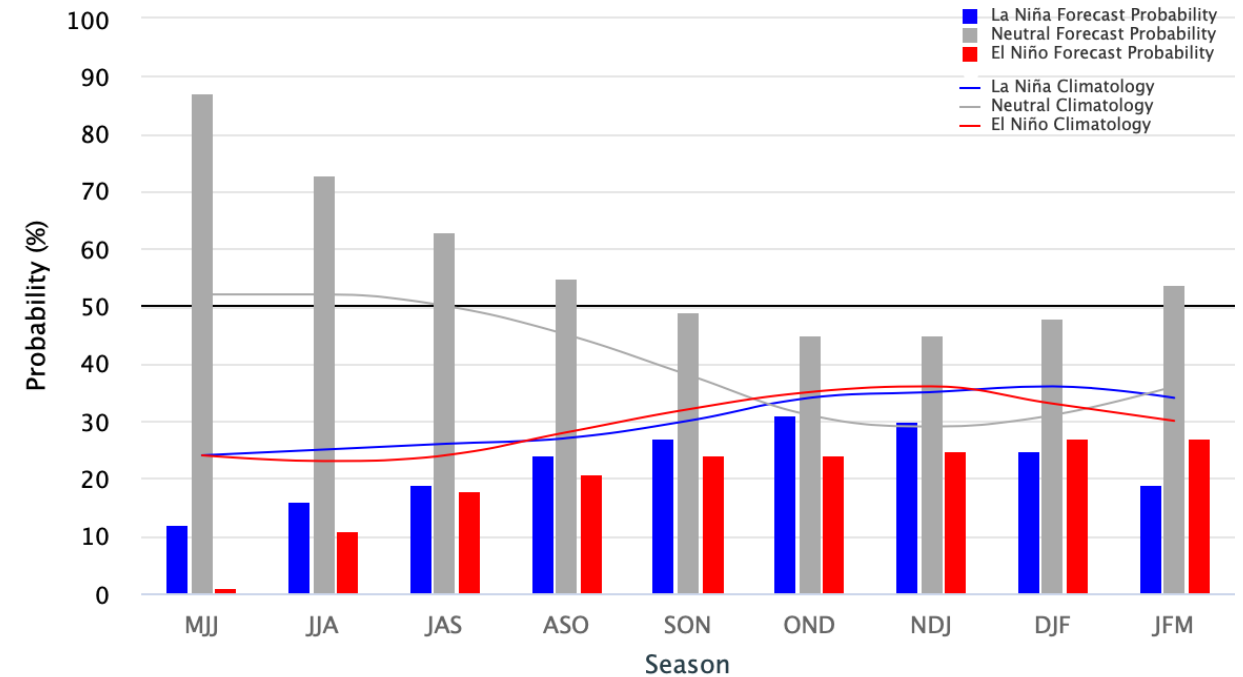


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### Mid-May 2021 IRI/CPC Model-Based Probabilistic ENSO Forecasts

ENSO state based on NINO3.4 SST Anomaly  
Neutral ENSO: -0.5 °C to 0.5 °C



**Figure 27-28.** Neutral conditions are likely to continue through the Northern Hemisphere summer 2021 (63% chance) and fall (55% chance).

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## Summary



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- Forecasts from the most highly skilled climate forecast models indicate that precipitation in central and northern New Mexico during July, August and September 2021 will most likely range from near to slightly below 1981-2010 climatological averages central and west and below average east.
- Climate model forecasts along with recent temperature trends indicate that temperatures in central and northern New Mexico during JAS 2021 will most likely range from slightly above to above average.
- Climate models are suggestive of an earlier than average NAM onset, particularly for far southwest NM.
- \*\*This outlook will be updated in early June 2021, once the June climate model runs are completed and posted.



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## Outlook Information

- **Outlook provided by National Weather Service Forecast Office Albuquerque, NM.**
- **For further information contact Andrew Church: [andrew.church@noaa.gov](mailto:andrew.church@noaa.gov) (505) 244-9150**

## References

Mitchell et al., *Gulf of California Sea Surface Temperatures and the North American Monsoon: Mechanistic Implications from Observations* – Journal of Climate 2002